Prior knowledge of the grading criteria increases Functional Movement Screen scores in youth soccer players

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Running Title: *Reliability of FMS in Youth Soccer Players*

Abstract

We sought to determine whether familiarity with the grading criteria of the functional movement screen (FMS) impacted the outcome score in elite youth soccer players. Thirty-two trained male youth soccer players (age 17 ± 1 yr) participated in a randomized control trial. Participants were randomly assigned to evenly sized control and experimental groups who each completed the FMS on two separate occasions. Participants in the experimental group were provided the FMS grading criteria between their first and second screens. Time synchronized video footage was used to grade the FMS using standardized criteria. Structured interviews were then carried out with selected participants ($n = 4$) in the experimental group to establish athletes' perception of the FMS. The experimental group had a large increase in overall FMS score from the first to the second screen in comparison to the control group ($\Delta 2.0 \pm 1.0$, $p < .001$, $d = 1.3$). Scores for the deep squat, hurdle step, and rotary stability tests components of the FMS all increased in the experimental group in comparison to the control group ($p < .05$). Thematic analysis of the interview data suggested that the participants in the experimental group improved their understanding between good and poor technique during the FMS. These findings support the notion that FMS scores are influenced by awareness of the grading criteria. As a consequence, the FMS may not be suitable for objectively predicting injury in youth soccer players.

Key Words: Football; injury; screening; sport; reliability

INTRODUCTION

The Functional Movement Screen (FMS) is a pre-participation screening tool, used in sport and physical therapy, which evaluates the fundamental movement patterns that underpin performance movement.[3,4,5] The FMS is widely utilized in sports contexts, most likely due to the relatively low cost and straightforward measurement of movement proficiency. McCall and colleagues,[27] for example, reported that the FMS was the most commonly used tool in the injury rehabilitation processes of premier league soccer clubs across the world. Data from several studies also suggests the FMS is sensitive enough to detect improvements in functional movement following 4-6 wk of corrective exercise programs.[7,14]

There is widespread agreement that the FMS has considerable to excellent inter- and intra-rater reliability.[11, 21, 29, 37] However, recent findings question the statistical validity of the FMS as a unidimensional measure of proneness to injury. In a large sample of US Marine officer candidates, the Cronbach alpha score for the overall FMS score was 0.39 which suggests poor internal consistency of the measurement tool.[19] In the same piece of research, an exploratory factor analysis revealed that FMS scores did not load as a single construct, likely due to the heterogeneous nature of the scoring criteria. Similar findings were reported in a sample of elite athletes, leading the authors to suggest that more focus should be centered on the scores of each separate component of the rather than the accumulated score.[23]

Recent work by Frost, Beach, Callaghan, & McGill[12] also highlights that prior knowledge of the FMS scoring criteria can significantly impact test-retest reliability. Specifically, FMS scores in a sample of firefighters improved significantly when the participants were provided with knowledge of the movement patterns required to achieve a perfect score. This potential impingement on the objective robustness of the FMS highlights a profound limitation of the

FMS that has potentially major implications in both research and applied contexts. Given the widespread implementation of the FMS in professional soccer[27] these reliability issues are worthy of further explanation within this context. This may be particularly relevant in youth soccer players where the impact of high training loads on the developing musculoskeletal system poses a concern.[18] To the best of our knowledge, however, no other research has explored this phenomenon within a sport context. This aim of this study, therefore, was to determine the effects of acquired knowledge of the grading criteria on FMS outcomes in elite youth footballers. The secondary objective was to investigate the athletes' perceptions of the FMS and the influence of the grading criteria on the athletes' approach to the FMS through qualitative data.

METHODS

Experimental approach to the problem

Youth players from a Scottish professional soccer academy were randomly allocated to either a control (n=16) or experimental (n=16) group by the first author on the basis of participant number. There were no significant differences in age, body mass, or stature between the two groups (all $p > .05$). Using an exploratory randomized control trial design with a mixed methods approach, each group were screened using the FMS test kit, (Functional Movement Systems, Functional Movement Systems., Chatham, Virginia), on two occasions, exactly one week apart in an indoor gymnasium. Participants were not made aware of which group they had been placed in prior to the first screen. In the intervening week between the first and second FMS, participants in the experimental group were provided with the standardized FMS grading criteria and had this explained to them as a group by the first author. Participants in the experimental group were given time to individually practice each component of the FMS although they received no feedback or further instruction at this stage. All participants were blind to the experimental hypothesis.

Subjects

Thirty-two male soccer players (age 17 ± 1 yr (range 16 to 18 yr); body mass 61.3 ± 6.6 kg; stature 171.0 ± 8.4 cm) volunteered to take part in this study, which had been approved by the School of Science and Sport Ethics Committee at the University of the West of Scotland and was conducted in accordance with the Declaration of Helsinki of 1964. The participants and their parents or guardians gave their informed consent in writing before starting the study and after the experimental procedures, risks, and benefits of participation had been explained. Participants who recently (< 6 wk), or at the time of screening, had a musculoskeletal injury, were excluded from participation. Participants had never previously undertaken a FMS prior to participation in this study. The sample size was calculated *a priori* using previous data by Frost and colleagues.[12]

Procedures

FMS tests were administered by the first author who was familiar with utilizing the FMS and had six years of experience delivering conditioning sessions to youth footballers. Pilot data confirmed that the author's administration and scoring of the FMS was repeatable (intra-class correlation coefficients (ICC) = 0.93, coefficient of variation = 1.6%). Time synchronized sagittal and frontal plane video footage were used, alongside the grading criteria, to obtain the FMS scores.[35] Participants' functional movement capacity was measured using the standard FMS Test Kit (Functional Movement Systems, Inc, Virginia, USA) following the protocol of Cook and colleagues.[4,5] The FMS is made up of seven components designed to detect limitations or asymmetries in movement patterns: the deep squat, hurdle step, in-line lunge, shoulder mobility test, active straight-leg raise, trunk stability push-up, and the rotary stability test.[4,5] To ensure consistency during the administration of all screens, a standard script was used to provide verbal instructions on the movements to each participant [7] and participants received no coaching or feedback during the screens.[13]

Each component of the FMS was scored from 0 to 3 with qualitative grading descriptors as follows: 3 = performance of the movement without any compensation; 2 = completion of the movement with some compensation; 1 = failure to complete the movement or loss of balance; 0 = pain associated with the movement pattern.[7] Three components (the shoulder mobility test, the trunk stability push-up, and the rotary stability test) were preceded by a clearing test which consisted of an isolated stretch of the same joints required for the functional movement. These clearing tests had only two possible outcomes: 1) pain during the stretch was absent leading to assessment of the functional movement as previously described or 2) pain was communicated and a score of 0 was allocated to this component of the FMS. All unilateral movements (hurdle step, in-line lunge, shoulder mobility test, active straight-leg raise, and the rotary stability test) were repeated on both sides of the body, with only the lowest score contributing towards the FMS score. Participants were not informed of their scores until the second screen were completed.

Interviews facilitated the investigation of athlete perceptions of the FMS and the influence of the grading criteria on the athletes' approach to the FMS. We conducted short, one to one interviews (~7 min) with four participants who exhibited the largest increase in total FMS score between the first and second screens (3.5 mean increase). The semi-structured interview guide covered; the athletes' perceptions of the FMS and the influence of the grading criteria on the athletes' approach to the FMS. The interviews were conducted by the first author, three days after the second FMS test, in a quiet area at the athletes' training venue with the FMS grading criteria in front of the athletes. The interviews were recorded and transcribed verbatim.

Statistical Analyses

Data are reported as mean ± standard deviation (s.d.). As the FMS components scores contain ordinal level data, Mann-Whitney U Tests were used to compare the overall FMS score and the score for each of the seven separate components between groups in the first FMS. Wilcoxon rank tests were used to compare the difference in FMS score and component scores between the first and the second screen within each group. Mann-Whitney U tests were also used to compare the change (Δ) in overall FMS score and FMS component scores between the first and the second screens between groups. The null hypothesis was rejected when $p < 0.05$. Effect sizes (Cohen's d) are included together with p values, where appropriate. Cohen's d effect sizes were interpreted as: small effect = 0.20–0.49, medium effect = 0.50–0.79, and large effect ≥0.80.[2]

Qualitative Analyses

Concurrent deductive and inductive thematic content analysis was adopted[36] to interpret the data, whereby the analysis was based upon both the two *a priori* themes within the interview guide and emergent themes within individual athlete responses. In order to maximize the trustworthiness of the qualitative analysis, the first author (a sport science practitioner experienced in the application of the FMS) and second author (an expert in qualitative research) analyzed the transcripts separately in four main steps. Firstly, the analysts read and reread the interview transcripts to be fully familiarized with the data. Secondly, data were coded data at a descriptive level and the codes were then grouped into meaningful themes. Finally, the analysts conducted a consensus validation process[8] to ensure that allocated codes and themes were the clearest expression of the data. Specifically, the two analysts iteratively discussed the codes and themes in relation to the raw data with critical questioning, exploration of alternative descriptions and reflection, until full agreement had been reached.

RESULTS

Quantitative

Data for the overall and component FMS scores for each group are presented in Table 1.

Please place table 1 here.

There were no differences in the overall FMS score or any sub-component of the FMS between groups at baseline (all $p > .209$). In the control group, there was no change in the overall FMS score ($p = .530$) or the deep squat ($p = .773$), hurdle step ($p = 1.0$), in-line lunge ($p = 1.0$), shoulder mobility ($p = 1.0$), straight-leg raise ($p = .586$), trunk stability push up ($p = .346$), or rotary stability (p = .773) components. In the experimental group, the overall FMS score increased from the first to the second screen (p = .002, d = 1.1) as did scores for the deep squat (p = .048, d = 0.6), hurdle step (p = .011, d = 0.9), and rotary stability (p = .048, d = 0.6) components. Scores for the in-line lunge (p = .371), shoulder mobility (p = .346), straight-leg raise (p = .766), and trunk stability push up (p = .149) components did not differ between the first and second screens in the experimental group.

The increase in the overall FMS score from the first to the second screen was significantly greater in the experimental group compared to the control group (p = .001, d = 1.3). For the in-line lunge (p = .325), shoulder mobility test (p = .576), straight-leg raise (p = .980), and trunk stability push-up (p = .653) components of the FMS there was no difference in the Δ score between groups. In comparison to the control group, the increase in scores for the deep squat (p = .033, d = 0.8), hurdle step (p = .003, d = 1.2), and the rotary stability test (p = .033, d = 0.8) were all significantly greater in the experimental group.

Qualitative

Please place table 2 here

Athlete perceptions of the FMS

Benefits of the FMS to footballers

When asked about the FMS' potential benefits, two participants suggested;

"I suppose it's just another piece of information, which isn't a bad thing"

"It gave me information on different ways to stretch"

Disadvantages of the FMS

All of the footballers mentioned weaknesses of the FMS screen, referring to a lack of sport specificity and little application to footballing performance;

"There is no particular area of my game that I feel the FMS directly influences"

More specifically, the lack of dynamic movement in the screening process was highlighted as a concern;

"I don't feel the FMS is realistic to football, as I didn't have to change direction at any point"

"I don't feel it is specific enough to the movements in football to benefit my game"

The players also suggested that repeated exposure to the FMS would elicit improved scores.

"*I feel like the more times I was asked to do the FMS the easier it would become, I feel if I was to do it again today I could get a better score than the last time I competed the screen*."

One player also questioned the sensitivity of the FMS for competitive level athletes, suggesting that once they were aware of the correct technique they had sufficient skill to copy the techniques required in the FMS.

"I feel that having been training 3 times a week for the last 3 years I can control my body enough to copy techniques, therefore I don't feel it could point out my weaknesses the second time"

The influence of the grading criteria

Impact of the Grading Criteria

All of the participants proposed that access to the grading criteria had improved their approach to the screening process with regards to their positioning and technique;

"*I feel that both the deep squat pictures helped me to understand that I needed to keep my back straight and where to position my feet"*

“The grading criteria showed me that I had to keep my shoulders up and my back straight and I then knew where to place my feet to balance”

Influential Elements of the Grading Criteria

In relation to the specific elements of the grading criteria which influenced their scores, the players suggested that the visual models provided by the pictures and the written descriptions assisted them;

“After seeing the pictures and reading the description, the screen became easier”

In particular, the players suggested that the photos of both good and poor technique on the grading criteria informed them of what to aim for and what to avoid;

“Seeing an example of the perfect technique, helped me to copy it”

“The example of the hurdle step, the poor example, shows a participant who is off balance, so I made sure the second time to concentrate on my balance”

“The example of poor technique showed me what to avoid”

Participants also indicated that seeing the grading criteria encouraged them to focus on getting a better score;

“*My approach changed as I had a better idea of what to do to get a better score, so I was aiming for the better score*”

DISCUSSION

The purpose of this study was to investigate whether prior knowledge of the grading criteria altered overall and individual component scores of the FMS in a sample of youth soccer players. The data demonstrates that, as expected, exposure to the grading criteria significantly increased the overall FMS score and several of the individual component scores in comparison to a control group. Specifically, the experimental group participants modified their movement patterns in the squat, hurdle step, and rotary stability components of the FMS to the extent that scores for these individual tasks improved significantly in comparison to a control group. Furthermore, the players interviewed suggested that repeated exposure to the FMS and an awareness of the scoring criteria assisted them to better differentiate between good and poor technique. The grading criteria also seemed to have a motivational influence as exposure to the criteria resulted in some players aiming for a better score. Finally, it was suggested that the players could effectively copy the FMS criteria due to the extensive soccer training they had undertaken, however, the FMS lacked relevance to soccer skills. While our quantitative findings are consistent with previous research[17], the present study is the first to demonstrate this effect using a randomized controlled trial in a sample of youth athletes. Furthermore, to our knowledge, the present study is the first to provide athlete perceptions of the FMS and the possible mechanisms via which scores increased in the experimental group. Whilst the findings are somewhat artificial in that participants were deliberately made aware of the grading criteria for the purposes of experimental research, they do highlight some key limitations with the objectivity of the FMS. Indeed, the current finding that the FMS techniques can be copied may cast doubts on claims[4,5] that the FMS can be used as an objective measurement tool to identify movement asymmetries.

Performances of motor skills are likely to improve simply as a consequence of repeated efforts, irrespective of the age of the participant.[14] Indeed, possible habituation effects of repeated FMS completions were recognized by the current youth athletes who suggested that repeat attempts at the FMS will likely produce an increase in their score. Furthermore, although within recent research there is clear agreement that the FMS has considerable to excellent inter- and intra-rater reliability[11,21,29,37] data assessing the test-retest reliability of the FMS is equivocal. Two studies demonstrate that the FMS has “good” and “high” test-retest reliability in samples of collegiate athletes and physically active adults, respectively.[29,35] On the other hand, Frost, Beach, Callaghan, and McGill[12] reported that FMS scores measured on two occasions in a sample of firefighters were not consistent, suggesting the FMS can only provide a momentary impression of general movement quality. However, care must be taken when interpreting these data as authors have used different metrics to assess test-retest reliability[12,29,35] and apply varying interpretations of ICC.[29,35] Using the ICC interpretation guidelines of Cicchetti (1994), the test-retest reliability of the FMS in the control group of the present study can be considered excellent (ICC = 0.94) contradicting the athletes’ suggestions of habituation effects. Nevertheless, the current findings demonstrate that if an individual were to obtain the grading criteria for the FMS then the test-retest reliability would likely be compromised.

An individual’s ability to execute movement patterns on a given day (and whether this remains stable when re-testing) can be influenced by myriad factors unrelated to physiological function. In particular, our findings support well documented assertions that movement patterns can improve with increased understanding of the task.[17] The grading criteria seemed to provide augmented written and visual instructions to the participants of how to produce a ‘better’ movement. Indeed, a wide range of research suggests that instructions and observational learning can improve appropriate movement force[33] and accuracy.[17] Furthermore, such motor learning appears to occur regardless of age[38] so it is unsurprising that the changes in FMS scores in our cohort of youth soccer players mirrored that found with adults.[12] Indeed, the current findings suggest that increased FMS scores can be achieved via brief psychological intervention without necessarily improving physical functioning.

Alongside acquired knowledge via instruction, there are a number of other psychological factors which are likely to affect FMS scores such as; an individual's perception of load,[4] focus of attention[39] goal setting[10] and their knowledge of FMS results and feedback.[32] In the current study, one likely mechanism via which FMS scores improved is participant goal setting. Indeed, the qualitative data suggests that participants invested more effort as they aimed to obtain a better score once they were exposed to the grading criteria. Furthermore, previous research suggests that knowledge of results and variations in feedback delivery influence performance on movement tasks.[32] Consequently, alongside the psychological effects of exposure to the FMS criteria, the provision of FMS feedback is likely to confound FMS scores. Whilst in the current study participants were not given feedback, within the FMS protocol there are no guidelines to encourage the standardized provision of feedback regarding FMS scores[4,5] which may further affect the reliability of the FMS.

Given the frequency of FMS use within soccer,[27] the current findings have important implications for the detection of injury risk and management of players. Indeed, accurate assessment of movement capacity is particularly important in young athletes as muscular imbalances have been shown to be a significant predictor of injury risk in elite junior soccer players[22]. Furthermore, there is some suggestion that deficiencies in basic motor skill performance may hinder the learning of more complex movement patterns[34] which clearly has consequences for the development of young soccer players. However, the accuracy and validity of the FMS to detect such injury risks and movement deficiencies is questionable due to the influence of the grading criteria. Indeed, the qualitative data questions the validity of the FMS as youth soccer players saw little relevance of the screening to their soccer performance. Work by Lockie and a colleague[25] supports this notion as FMS scores were found not to predict performance in a range of team sport-specific tests. As aforementioned, some research has suggested that the FMS score can be used to predict injury[20] but this finding is not consistent across the literature. Indeed, there are several other studies, including a recent meta-analysis, that suggest the FMS was not sufficiently accurate for injury prediction.[1,9] Taken together, current and previous findings question the use of the FMS as a diagnostic tool and a reliable determinant of movement dysfunction or impairment.

Previous research has demonstrated that a FMS score below 14 increased the risk of injury in a cohort of American Football players.[20] A threshold score of 14, therefore, is often used as the pivotal decision factor on whether or not to implement a corrective intervention programme.[21] In the present study the majority of participants (n=26, 81%) would be classified as "at risk" on the basis of these criteria which would seem to warrant employing a team intervention to correct basic movement skills. Conversely, it has been established that the FMS scores can be impacted by maturation status in young soccer players.[24] These authors reported that the FMS score was significantly higher in the older age group of players (under 16 years) compared to the two younger groups (under 11 and 13 years). This can likely be explained by the rapid gains in muscular strength and power that occurs during the peak growth phases of puberty.[39] Practitioners should therefore be cognizant of the potential effect of maturation when interpreting FMS metrics. Despite this, the mean FMS scores of participants in the present study are lower than those typically reported elsewhere in the literature for soccer players of a similar age.[24] On the other hand, overall FMS scores in a cohort of young elite ice hockey players were similar to those in the present study.[31] The reasons for the low scores in the current study are uncertain and while it may be a consequence of genuine movement dysfunction, the modifiable nature of FMS scores means that a plethora of alternative explanations cannot be ruled out (e.g., athletes' previous experiences, goals and motivation).

In terms of the generalizability of the current findings, it is important to highlight that the athletes suggested that they were able to effectively adapt their movements using the grading criteria due to the high volume of training they undertake and their resultant high levels of fitness. Therefore it is possible that individuals with lower levels of fitness or strength might be less able to adapt their movements with increased knowledge of the FMS grading criteria. Conversely, one may speculate that more mature athletes, typically with a higher FMS score at baseline, may be less sensitive to exposure to the scoring criteria or indeed to any intervention that is designed to increase the FMS score. Furthermore, it is important to highlight the results of both the current study and Frost et al,[13] found that only certain FMS components were altered by awareness of the grading criteria. Specifically, in both studies the squat and hurdle increased with criteria exposure, whereas the push up and active leg raise remained unaltered. These findings could indicate that some components of the FMS are more objective and reliable than others. As such, we uphold the view that attention should be given to the individual components of the FMS rather than the solely the overall score FMS[23] and that further investigations are needed to establish the utility of each FMS component.

The present study demonstrates that the overall FMS score, in addition to several of the individual components, can be positively influenced by increased awareness of the scoring criteria in youth soccer players in comparison to a control group. Participants in this study had the perception that the FMS was of limited relevance to their performance and noted that their score would likely increase with repeated performances. Participants in the experimental group were able to gain an understanding of the differentiation between good and poor technique in the FMS and mentioned that visual reference to the desired movement patterns was a considerable advantage. These data, therefore, add further weight to the argument that the uncertainty over the reliability of the FMS limits the potential application to objectively assess functional movement in athletic populations.

PRACTICAL APPLICATIONS

Practitioners who continue to implement the FMS in soccer academies as a pre-screening tool or as a component of the injury rehabilitation process should carefully consider whether they should withhold scoring criteria from the players to prevent this influencing the outcomes. Alternatively, they could inform their players of the scoring criteria in advance of baseline testing in attempt to minimize an augmented change in FMS score following any intervention. However, the FMS seems to be, at best, weakly associated with physical performance and movement competency.[28,30] This may because the standard FMS is not sufficiently sensitive to capture biomechanical differences which influence performance in physically rigorous activities such as soccer[15]. Instead, strength and conditioning practitioners should consider a different approach. For example, focus should be orientated towards developing an alternative version of the FMS that is more specifically orientated towards the biomechanical movements of the sport. This may include the introduction of a component of external load which has been previously shown to provide better predictors of performance outcomes[15] and may be more successful at predicting injury risk.

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